Conservation Status of *Botrychium lineare* (slender moonwort) in Montana

Prepared for the

U.S. Fish and Wildlife Service

By

Drake Barton and Sue Crispin

Montana Natural Heritage Program
Natural Resource Information System
Montana State Library

February 2004

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Agreement Number
E-5-R-14, Amendment 2

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This document should be cited as follows:

Barton, D. and S. Crispin. 2004. Conservation Status of *Botrychium lineare* (slender moonwort) in Montana. Report to the U.S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena, MT. 16 pp. plus appendices.

EXECUTIVE SUMMARY

Historic records for *Botrychium lineare* (slender moonwort) extend over a broad range in North America, from Quebec and New Brunswick in eastern Canada to central California. Recently documented populations of this plant are known from only Alaska, Washington, Oregon, Colorado, Wyoming, Montana the Canadian province of Alberta and the Yukon Territory. In 1999 a formal petition was filed with the United States Fish and Wildlife Service (USFWS) to seek protection for slender moonwort under the Endangered Species Act (ESA) as threatened or endangered.

Field surveys were conducted in 2003 to relocate populations of slender moonwort that were previously documented in Montana and to examine additional areas in the attempt to locate new populations. These surveys revisited three of the four previously reported populations in Montana and resulted in the discovery of one new population. The Montana state rank for *B. lineare* remains at S1 with the likelihood that additional populations, especially in native habitat, will be located in the future.

The outlook for long-term survival of this species improves with each additional population discovered. However, most of the known populations have had few plants in the years they were surveyed, are in relatively vulnerable roadside habitats, and are subject to the dangers inherent in small, localized populations.

ACKNOWLEDGMENTS

We would like to thank the many individuals who provided information and support. Mary Clare Weatherwax and Dan Carney with the Blackfeet Tribal Government helped with permission for surveys within the Reservation. Toby Spribille provided useful background information. Botanists with the Natural Heritage Network provided information on occurrences in their states. They include David G. Anderson, Colorado Natural Heritage Program; Sue Vrilakas, Oregon Natural Heritage Information Center; Jim Morefield, Nevada Natural Heritage Program; Ben Franklin, Utah Natural Heritage Program; Joyce Gould, Alberta Natural Heritage Information Centre; Florence Caplow, Washington Natural Heritage Program; Roxanne Bittman, California Natural Diversity Database; Jenae Dixon, Conservation Data Center Idaho Department of Fish and Game; and Curtis Bjork, Montana Natural Heritage Program. We would especially like to thank Tara Carolin, Ecologist with Glacier National Park, for a great deal of helpful information and Donald Farrar at Iowa State University for working through the genetics of various moonworts and keeping them straight.

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I. INTRODUCTION

Botrychium lineare W.H. Wagner (slender moonwort) was described as a new species by Warren H. Wagner and Florence S. Wagner in 1994, in the *American Fern Journal*. The Wagners first collected this plant in 1978 in the Mission Mountains of Lake County, Montana, although the type specimen came from a subsequent collection made in 1992 in the Lostine River Canyon in Wallowa County, Oregon. The Lostine River population was revisited in 1993 by the Wagners and consisted of 14 individuals at that time (Wagner and Wagner 1994).

Other recently documented occurrences of *Botrychium lineare* include:

- two plants found in a grassy area under spruce trees in Wallowa County, Oregon (Hurricane Creek Meadows), first documented in 1981;
- a population discovered in 1989 in El Paso County, Colorado along the road to Pikes Peak, with 45 plants in knee-high grass on a hillside;
- another small population recorded in the Pikes Peak area of Colorado; and
- a population discovered in 1997 in Ferry County, Washington, in a floodplain along a creek, with 10 plants counted in 2002 (Washington Natural Heritage Program).

In addition, four other new state/provincial records have been reported in the past year:

- Black Hills, Crook County, Wyoming in Dugout Gulch; June 2003 (Farrar pers. com. 2004).
- Kluane National Park, Yukon Territory, Canada, along Soldier's Summit Trail in June, 2003 (Farrar pers. com. 2004).
- Wrangell-St. Elias National Park, in southeast Alaska near Chisana; June 2003 (Farrar pers. com. 2004).
- Alberta, Canada, along Drywood Creek; 2002 (Williston 2003).

Other records are older and/or are based on herbarium specimens only, with none recently confirmed extant since the original collection. These include collections from:

- 1902 in Bonaventure County, Quebec, Canada;
- 1904 in New Brunswick, Canada (Wagner and Wagner 1994);
- 1905 in Utah (Franklin per. com. 2003);
- 1925 in Idaho's Upper Priest River area, under shaded woods in sandy soil;
- 1942 in Rimouski County, Quebec, Canada;
- 1947 in gravelly, poorly drained soil in Boulder County, Colorado;
- 1968 in Fresno County, California (this population of approximately 85 plants above a trail was documented in 1968 and is presumed to be extant) (Bittman per. com 2003); and
- 1992 in Colorado's Lake County near Leadville, Colorado (previously misidentified) (Federal Register 2001).

In July of 1999, a petition was initiated to list *Botrychium lineare* as threatened or endangered under the Endangered Species Act (Carlton 1999). The petition was based on the very few populations known to be extant, and the small number of individual plants within these populations. It was noted that several older populations had not been relocated for many years and may be extirpated. Of the few populations noted as extant, the numbers of individuals counted were small, with 45 being the largest. A total of less than 100 documented individual plants was cited in the petition as evidence of the rarity of this species. Other stated reasons included potential habitat loss to woody encroachment, risks associated with recreational use, potential impacts

Figure 1. *Botrychium lineare*

from mining or logging and potential development impacting the population on private land in Oregon.

Prior to the listing petition (but not referenced in it) a population was found in Glacier National Park (Glacier County, Montana) along the road from Babb to Many Glacier at Apikuni Flat. This population was discovered in 1998 immediately adjacent to the roadway and approximately 20 to 30 plants were noted at that time. After the petition was filed in 1999, two additional populations (described below) were reported in Montana, bringing the total of reported occurrences in the state to four.

In 2000, two populations were reported in Montana. One was found in roadside gravels along Highway 89 close to Saint Mary Ridge within the Blackfeet Indian Reservation. This population was recorded as having 100 plants at that time. The other population was located just south of the Canadian border within Glacier National Park along Highway 17 in the Chief Mountain area, also in roadside gravels. Seven individuals were observed at the time of discovery. Neither of these reported localities were documented by collection of a specimen.

The four previously documented Montana localities described above will be referred to in this report as the Mission Mountains population, the Apikuni Flat population, the Saint Mary Ridge population, and the Chief Mountain population. The purpose of the current study was to relocate these populations, document their current status, obtain detailed habitat information, and use that information to identify and survey other areas of potential habitat.

II. METHODS

Field surveys were conducted in the summer of 2003 to relocate and evaluate previously documented or reported occurrences of *Botrychium lineare* in Montana, collect habitat and population data, and to survey for new populations in areas of suitable habitat near known populations and in areas where *Botrychium* "communities" had been identified. All work was conducted by staff or contract biologists of the Montana Natural Heritage Program, which is the state's clearinghouse for information on native species and habitats, emphasizing those of conservation concern.

Prior to beginning fieldwork, available literature was reviewed to determine the location of recorded populations and phenology of the species. When available, precise latitude and longitude coordinates were obtained and loaded into a handheld GPS (global positioning system) unit as an aid to relocating the recorded populations. The Ecologist at Glacier National Park was consulted for information about the location and phenology of the Apikuni Flat population.

To focus surveys in new areas, ecological characteristics of known localities were evaluated for key search parameters; areas fitting this "search image" were selected for survey in both native and roadside habitats.

The Blackfeet Tribe gave permission to survey (but not collect) within the Reservation along Highway 89, the site of the Saint Mary Ridge population (Weatherwax and Carney per. com. 2003). We applied unsuccessfully for a Tribal research permit to survey Montana's oldest locality for *Botrychium lineare* in the Mission Mountains.

Fieldwork was conducted between June 16 and July 1, 2003. Plants found at lower elevation sites were mature during the earlier surveys but the plants found at the higher elevation sites needed additional days to develop fully for accurate field identification and were visited several times. At each site, data were collected on associated species and their abundance, soil texture and moisture, slope, aspect, elevation and any negative impacts or threats to these populations. Data were recorded on the Heritage Program's Plant Species of Concern Survey Form, and photos were taken. Other Montana Species of Concern, especially *Botrychium* species, were also fully documented when located.

As a result of this survey work, three of the previously reported Montana populations were successfully relocated, including sites at Apikuni Flat and Saint Mary Ridge. The site in the Chief Mountain area was located and specimens were collected to verify identification. In addition, a new *Botrychium lineare* population was discovered in Glacier National Park near Siyeh Bend along the Going-to-the-Sun Road, and specimens were collected for identification purposes.

To verify accurate identification of *Botrychium lineare,* specimens were and sent to Donald Farrar at Iowa State University for starch-gel enzyme electrophoresis. This process has been used effectively to distinguish species of *Botrychium* and to determine the relationships between species. These specimens will reside at the Iowa State University herbarium.

Nomenclature for documenting associated species follows Lesica 2002.

III. Species Information

A. Classification

1. SCIENTIFIC NAME: *Botrychium lineare* W.H. Wagner

2. COMMON NAMES: slender moonwort, linearleaf moonwort, skinny moonwort, narrow-leaf grapefern, and others.

3. FAMILY: Ophioglossaceae (Adder's-Tongue Family); some researchers have now recognized the new family Botrychiaceae.

4. SIZE OF GENUS: Wagner & Wagner (*Flora of North America* Vol. 2 1993) number the size of the genus at 50-60 species worldwide, and recognize 30 species of *Botrychium* in North America. (Notably absent from that treatment is *Botrychium lineare*, which was described after the book's publication). Several additional new species have been proposed and are under review or have now been recognized as distinct species. Williston (2001) puts the worldwide number at approximately 70 species, which may better reflect the results of recent research. In 2003, the Montana Natural Heritage Program database documented 17 species of *Botrychium* in Montana, as well as the hybrid *B.* x *watertonense*.

5. PHYLOGENETIC RELATIONSHIPS: *Botrychium lineare* belongs to the subgenus *Botrychium*, which is the largest subgenus with approximately 26 species currently recognized. Subgenus *Botrychium* is characterized by its normally small size and simple leaf morphology. The leaf blades (trophophore) of many species are simple (1-pinnate) with the spore-bearing stem (sporophore) arising from the main stalk well above ground level (this can be close to the ground in some forms of *B. simplex*). *Botrychium lineare* is most closely related to *Botrychium campestre*. These two species are very similar morphologically and share a high degree of genetic similarity (Farrar 2001). The genetics of *Botrychium* is a field of active research and will likely continue to yield new theories and insights on taxonomic relationships within the group.

B. Present Legal or Other Formal Status

1. NATIONAL

a. LEGAL STATUS: After a 12-month petition finding on June 6, 2001 the United States Fish and Wildlife Service (USFWS) announced that listing of *B. lineare* as threatened under the Endangered Species Act (ESA 1973, as amended) is warranted but precluded by higher priority species. It was subsequently added to the ESA candidate species list. On June 6, 2002 the USFWS announced an annual notice of recycled petition finding for *B. lineare*.

b. HERITAGE RANK: Definitions for global and state ranks are provided in Appendix A.

2. STATE

a. MONTANA

i. LEGAL STATUS: None.

ii. HERITAGE RANK: *Botrychium lineare* is ranked S1 in Montana, indicating that it is at high risk because of extremely limited and/or rapidly declining numbers, range and/or habitat, making it highly vulnerable to extirpation in the state. With only four recently surveyed populations and one additional historic population, rarity is still the biggest factor in this species' Montana state rank.

b. COLORADO

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The Colorado Natural Heritage Program ranks *B. lineare* as S1, based on one historic and two extant populations.

c. IDAHO

i. LEGAL STATUS: None.

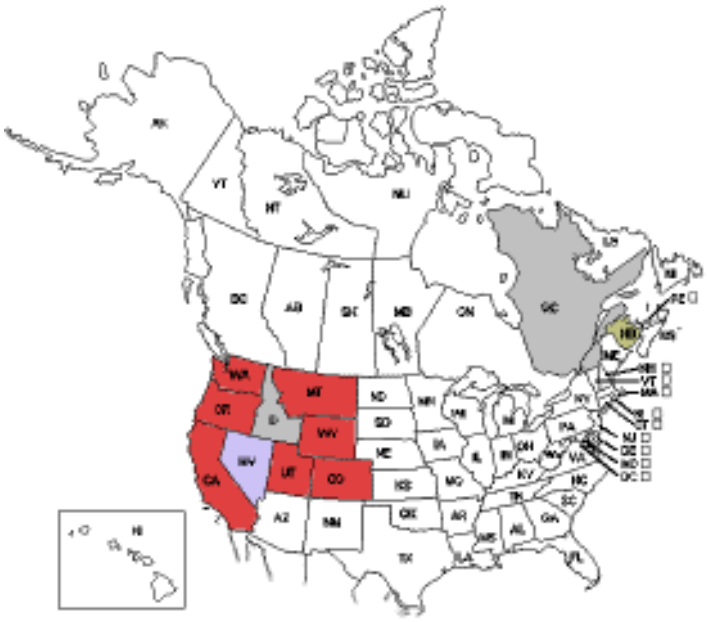


Figure 2. Global status of *Botrychium lineare*. Red indicates an S1 status, purple indicates an SR (reported) status, gray indicates an SH (historical) status, and green indicates an SU (unrankable) status. Map represents available information current through 2003.

ii. HERITAGE RANK: The Idaho Conservation Data Center (Department of Fish and Game) ranks *B. lineare* as SH, based on one historic collection.

d. CALIFORNIA

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The California Natural Diversity Database ranks *B. lineare* as S1.3, with the "3" indicating lack of notable threats.

e. NEVADA

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The Nevada Natural Heritage Program ranks *B. lineare* as SR, based on one recent (2001) collection that is still pending verification.

f. OREGON

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The Oregon Natural Heritage Information Center ranks *B. lineare* as S1, based on two extant populations.

g. UTAH

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The Utah Natural Heritage Program ranks *B. lineare* as S1, based on one historic population.

h. WASHINGTON

i. LEGAL STATUS: Threatened.

ii. HERITAGE RANK: The Washington Natural Heritage Program ranks *B. lineare* as S1, based on one extant population.

i. WYOMING

i. LEGAL STATUS: None.

ii. HERITAGE RANK: The Wyoming Natural Diversity Database ranks *B. lineare* as S1, based on one recently confirmed population.

C. Description

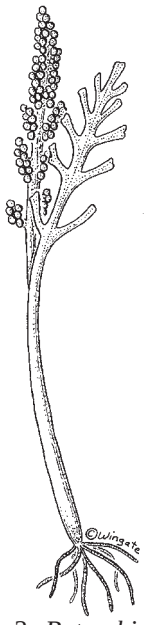


Figure 3. *Botrychium lineare* illustration by Janet Wingate from 'Colorado Rare Plant Field Guide'

1. GENERAL NON-TECHNICAL DESCRIPTION: Slender moonwort is a perennial fern-like plant. A single stalk emerges above ground from an underground rootstock. This stalk is divided into a sterile leafy branch and a fertile spore-bearing branch, with the leafy portion divided into segments (pinnae) on either side of a main axis (rachis). These segments are perpendicular to the rachis or somewhat ascending; they are well spaced and are slender without much expansion at the tips. However, the tips are often split or deeply incised into slender lobes. The fertile branch is 1-2 times the length of the sterile branch and consists of a central stem with short side branches that bear many round grape-like structures containing the spores. The total height of the plant is up to 20 cm (4 inches).

2. SIMILAR SPECIES: *Botrychium campestre* is the closest relative and is similar in appearance to *B. lineare*. The two species are separated morphologically by several subtle differences. In *Botrychium campestre* the leaf rachis is broader and fleshy with the leaf segments closer together and sometimes overlapping. The individual segments are relatively shorter and broader with more divisions or lobes at the ends than in *B. lineare*. *B. campestre* also has a denser fleshy spore mass. *Botrychium ascendens* can also be quite similar, but the individual leaf segments are more strongly upright (ascending) and are generally more wedge-shaped, with the broader ends being more finely lobed or toothed. Unlike *B. lineare*, *B. ascendens* frequently bears some sporangia on the lower leaf segments.

Rare *Botrychium* species often co-occur in what have been called "genus communities." Our surveys in 2003 for *Botrychium lineare* resulted in the discovery of several new populations of other globally rare *Botrychium* species, including three new occurrences of *Botrychium ascendens* (G2G3), one new occurrence of *B. paradoxum* (G2), and one new occurrence of *B. hesperium* (G3G4). *Botrychium ascendens* and *B. hesperium* were found in a new "*Botrychium* community" in the southeast portion of Glacier National Park near Two Medicine Lakes.

D. Geographical Distribution

1. RANGE: *Botrychium lineare* has been reported historically over a wide geographic range. The earliest collections on record are from eastern Canada — Quebec in 1902 and New Brunswick in 1904 (Wagner and Wagner 1994). The earliest U.S. collection is from 1905 in Salt Lake County, Utah. Other localities include three sites in Colorado, one in California, another in Quebec, one in Idaho, one in Washington, two in Oregon, one in Alberta, Canada (Williston 2003) and five in Montana. In addition, Donald Farrar (pers. com. 2004) has just reported confirmation of *B. lineare* collections from the Black Hills of Wyoming, Kluane National Park in the Yukon Territory, and Wrangell-St. Elias National Park in southeastern Alaska.

The first Montana collection was made in 1978 in the Mission Mountains. This site is located on the Flathead Indian Reservation, and is the only location in Montana that lies west of the Continental Divide. In 1998, a second and larger population was located in Glacier National Park right beside the road from Babb to Many Glacier, near an area called Apikuni Flat.

In 2000, two more localities were reported from the same region of Montana. The first was just south of the Canadian border on Highway 17 in the Chief Mountain area within Glacier National Park. The other locality was along Highway 89 within the Blackfeet Indian Reservation near Saint Mary Ridge. During our 2003 surveys, another new population was located within Glacier National Park, along the Going-to-the-Sun Road at Siyeh

Bend. These last four populations are all within Glacier County, Montana.

2. EXTANT SITES: Montana occurrences of *Botrychium lineare* are summarized in Table 1 and in Figure 4. Each of the four recently documented occurrences is further described in the following paragraphs.

The Apikuni Flat population was documented with 57 plants in 2003 (20-30 plants in 1998). This population extends along a 1/3-mile strip on either side of the road with the greatest concentration of plants occurring on the south side. The plants are found in the roadside gravels very close to the asphalt surface. The population appeared healthy in 2003, though many plants were injured by routine mowing, foot trampling and vehicle traffic. The plants collected from this population in 2003 have been preliminarily confirmed by Donald Farrar as *Botrychium lineare* (Farrar pers. com. 2003). This locality also supports *Botrychium hesperium* (G3G4) and *B. paradoxum* (G2) in nearby native grassland.

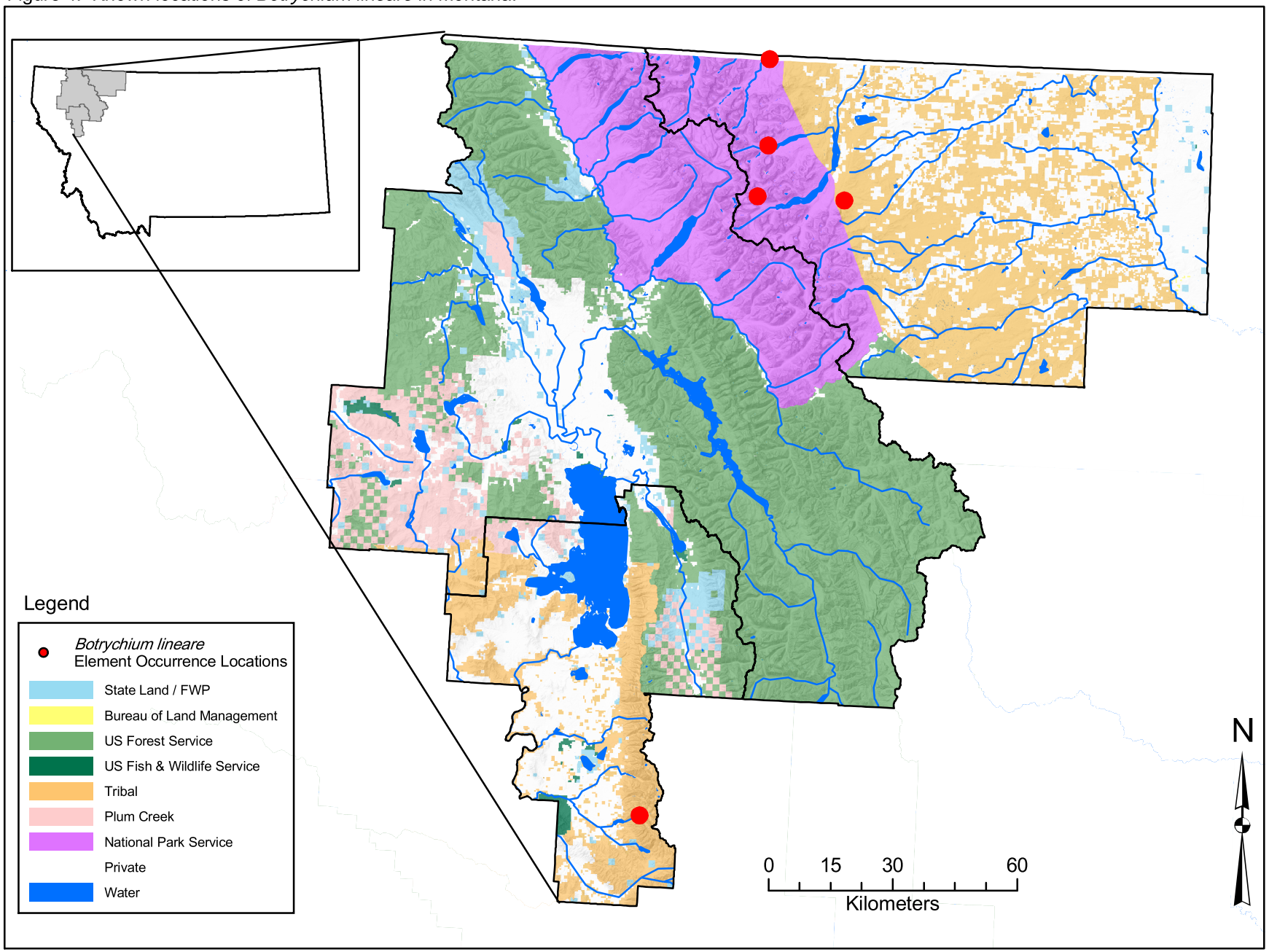
The Saint Mary Ridge population along Highway 89 was counted at 27 individuals in 2003 (100 plants were reported in 2000). The plants are in two clusters several hundred yards apart. No impacts to this population were observed, though on June 30th most individuals were dried up and several may not have completed spore development. No voucher specimen was collected at this location for genetic analysis and verification, as it lies within the Blackfeet Indian Reservation. However, this population is very close in appearance to the Apikuni Flat population, and identification is as certain as possible using field characteristics. Also present at this locality is *Botrychium ascendens* (G2G3).

The Chief Mountain locality along Highway 17 was re-visited in 2003. The *Botrychium* plants are found very close to the road shoulder, in the ditch

Table 1. All Element Occurrence (EO) records for *Botrychium lineare* W. H. Wagner in Montana. Selected descriptive fields are presented for each EO, taken directly from the Heritage database.

EO Number	County	Survey Site	Element Occurrence Data	General Description
001	Lake	**Mission Mountains** east of Saint Ignatius on the Flathead Indian Reservation.	From a 1978 collection by W.H. and F.S. Wagner. Only 2 plants were observed.	Found along the banks of a steep woodland trail at Mission Falls.
002	Glacier	**Apikuni Flat** on the road to Many Glacier, in Glacier National Park; south side of the road.	Originally discovered in 1998, with 20-30 plants reported. Resurveyed in 2003, with 57 plants counted.	Found in roadside gravel just off the pavement. Little canopy cover. Associated species include: *Populus balsamifera, Fragaria virginiana, Poa pratensis. Botrychium paradoxum* and *B. hesperium* also occur at this locality.
003	Glacier	**Chief Mountain** about 0.5 miles south of the Canadian border; east side of the road.	First documented in 2000 with 7 plants reported. In 2003, population was a mix of *B. ascendens* and 9 plants identified as *B. lineare* appeared to be genetically intermediate with *B. campestre.*	Found in the roadside gravel in a shallow drainage ditch adjacent to the pavement. Associated species include: *Phleum pratense, Hedysarum sulphurescens, Fragaria virginiana.*
004	Glacier	**Saint Mary Ridge** about 4.5 miles south of Saint Mary on Hwy 89; east side of the road.	First documented in 2000 with 100 individuals. In 2003, 27 individual plants were counted.	Found in the roadside gravel in a broad and deep drainage ditch adjacent to the pavement. Associated species include: *Pentaphylloides fruticosa, Achillea millefolium, Centaurea maculosa. Botrychium ascendens* is also present at this locality.
005	Glacier	**Siyeh Bend** along the Going-to-the-Sun Road in Glacier National Park; west side of the road.	A new occurrence discovered in 2003 with 37 plants counted, including both typical *B. lineare* and at least one intermediate with *B. campestre.*	Found in the roadside gravels along the shoulder of the road pavement. Associated species include: *Pentaphylloides fruticosa, Juniperus communis, Fragaria virginiana, Bromus inermis.*

Figure 4. Known locations of *Botrychium lineare* in Montana.



and along the adjacent bank. *Botrychium ascendens* is also reported from this site. Many *Botrychium* plants were found in 2003, with nine closely resembling the *B. lineare* plants at the other localities. Preliminary findings by Donald Farrar identified these plants as genetically intermediate between *B. lineare* and *B. campestre* (Farrar pers. com. 2003).

The Siyeh Bend population was discovered in 2003 along the Going-to-the-Sun Road in Glacier National Park. We counted 37 plants of *Botrychium lineare* in two groups. The first subpopulation is near Siyeh Bend and the second lies about ¾ mile farther south along the road. The plants at this locality differed somewhat in appearance from other populations of *B. lineare* in the area, though they shared many *B. lineare* characteristics. Preliminary results from Donald Farrar found one specimen to be among the "best" or most typical *B. lineare* specimens submitted from our 2003 Montana collections, and another specimen to be genetically closer to *B. campestre* than *B. lineare* (Farrar pers. com. 2003).

Population counts noted above and in Table 1 cannot be relied upon for an accurate assessment of the numbers of plants actually present. Much of the life-cycle of *Botrychium* plants occurs underground, with the number of aboveground sporophytes fluctuating from year-to-year, as individual plants may not appear every year (Chadde and Kudray 2001). Prolonged dormancy has been documented for several *Botrychium* species (Johnson-Groh and Farrar 1993, Lesica and Ahlenslager 1996).

3. HISTORICAL AND EXTIRPATED POPULATIONS: The first population of *Botrychium lineare* recorded in Montana was in the Mission Mountains of Lake County on the Flathead Indian Reservation. This population was first observed in July 1978, when only two plants were found (Wagner and Wagner 1994). We sought but were not granted a research permit from the Tribe to resurvey this site. No records exist to suggest that any surveys have been conducted to relocate this population since the original collection in 1978.

4. PRESENT SITES WHERE STATUS REMAINS UNKNOWN: The status of the Mission Mountains locality in Lake County, Montana remains unknown and requires resurvey, if a research permit can be obtained from the Tribe.

5. UNVERIFIED/UNDOCUMENTED REPORTS: None.

6. AREAS SURVEYED BUT SPECIES NOT LOCATED: Considerable area was surveyed as part of this project, most of which was within, or close to, the east side of Glacier National Park. Additional populations were deemed most likely to be found in the general vicinity of existing populations. Survey effort was divided between a variety of native sites and road edges in the general vicinity of existing populations. Detailed maps of areas surveyed are on file and available from the Montana Natural Heritage Program.

7. AREAS OF UNSURVEYED POTENTIAL HABITAT: Given the diversity of habitats in which this species has been found, the extent of potential habitat could be quite large. For example, many miles along Highway 89 on the Blackfeet Indian Reservation appear to represent good potential habitat. In addition, a variety of native vegetation types may provide potential habitat, including grassland openings, woodland edges, cobble borders along streams, the mist spray or splash zone of waterfalls, re-vegetating avalanche shoots, and recently burned forest land in the early stages of plant succession. Another potential habitat, not addressed during the field surveys in 2003, is alpine or sub-alpine meadows.

Botrychium plants are small and are still commonly overlooked by many people, including trained botanists. Any training opportunities to engage and familiarize more individuals with this and other globally rare *Botrychium* species may pay off by providing a search image and habitat profile to people who may be in a position to survey appropriate habitat, but have never had the opportunity to observe the plant.

Glacier National Park has several ongoing vegetation survey projects, including weed

monitoring, vegetation mapping, and climate change studies involving vegetation in alpine habitats. These projects present opportunities for field workers to search for *Botrychium* species in a variety of habitats. After the fires of 2003 in Glacier National Park, any work done on post-fire vegetation changes would provide particularly good opportunities to search for *Botrychium* species in native successional habitats.

E. Habitat

Botrychium lineare is an early- to mid-succession species that has been found throughout its range in a wide variety of habitats. These include mid-height grasslands, grazed rangelands, a limestone shelf on a steep slope, a woodland trail, along a creek floodplain, roadside gravels and in grass under conifers.

Figure 5. *Botrychium lineare* along Highway 89 in roadside gravels

Here in Montana *Botrychium lineare* is mostly associated with the gravel edges of paved road systems. This poses challenges in selecting areas for survey, but also provides a wide range of apparently suitable habitat in which the species may occur. Montana populations, with the exception of the historic Mission Mountains site in Lake County, which was found along a steep woodland trail, were all found in habitats with many similarities. All were along roadways in gravelly shoulders created during road construction.

The three reported populations within Glacier National Park are very close to the road surface, with the majority of the plants within just a few feet of the pavement and some plants only inches away. The Saint Mary Ridge population on the Blackfeet Indian Reservation along Highway 89 is farther off the road's edge on the slopes of a broad, gravelly drainage ditch created during road construction.

In all four locations, canopy cover from associated vegetation is low, allowing ample direct sunlight for much of the day. In Glacier National Park this condition is maintained by mowing several times during the summer months, and along Highway 89 it may just be a result of poor growing conditions. The slope/aspect for all these populations is nearly flat.

Associated vegetation is often sparse and some associated species are non-native. *Fragaria virginiana* (wild strawberry) is present at four of the Montana sites; two also have *Pentaphylloides fruticosa* (shrubby cinquefoil), *Cerastium arvense* (field chickweed) and *Juniperus communis* (common juniper), as well as *Picea engelmannii* (Engelmann's spruce) nearby. Other prominent species at individual sites include *Taraxacum officinale* (common dandelion), *Lupinus sericeus* (silky lupine), *Phleum pratense* (Timothy), *Poa alpina* (alpine bluegrass), *Bromus inermis* (smooth brome), *Poa pratensis* (Kentucky bluegrass), and *Arctostaphylos uva-ursi* (bearberry). Habitat data are summarized in Table 2.

The roadside gravels that support these populations are well drained, and during the summer months soil surface moisture is minimal. However, roadside habitats receive water runoff from the paved surface, thus providing increased available moisture, especially during the spring and early summer growing season. The Apikuni Flat and Chief Mountain populations are located where a tall forest canopy is near enough to provide shade during part of the daylight hours. The Saint Mary Ridge population and the Siyeh Bend population are both located at a higher elevation and would most likely have snow piled along the roadside later into the spring season. Therefore, sufficient available moisture in the spring appears to be a common factor among these sites.

Some species of *Botrychium* occupy a diversity of habitats across their range, suggesting that they

Table 2. Habitat Information for all recently confirmed sites of *Botrychium lineare* in Montana.

Site Location	Habitat	Aspect/Slope	Canopy Cover	Soil Moisture	Exposure
Apikuni Flat population	Immediately adjacent to the pavement in roadside gravel and compact fill. High percentage (75%) gravel and bare ground.	North and south 0-5% slope	Tree 7% Shrub 12% Forb 25% Graminoid 10%	Dry at time of survey	Partial shade from surrounding tree cover to south.
Chief Mountain population	Immediately adjacent to the pavement in roadside gravel and compact fill. High percentage (75%) gravel and bare ground.	Northeast to southwest 0-5% slope	Tree T% Shrub T% Forb 35% Graminoid 12%	Dry at time of survey	Full sun much of the day, partial shade from road burm and trees to the south.
Saint Mary Ridge population	Approximately 30 feet from pavement in roadside gravel and compact fill. High percentage (76%) gravel and bare ground.	North 2% slope	Tree 1% Shrub 3% Forb 12% Graminoid 5%	Dry at time of survey	Full sun much of the day, partial shade from road burm.
Siyeh Bend population	Immediately adjacent to the pavement in roadside gravel and compact fill. 35% gravel and bare ground. This site has more litter on the ground.	West to south 4% slope	Tree 8% Shrub 3% Forb 10% Graminoid 25%	Dry to moist	Full sun much of the day. Vegetation was higher and provided some shading.

may not be highly habitat specific, or that habitat requirements may vary geographically. *Botrychium* has also been documented at sites disturbed by natural processes or human activities, suggesting that at least some moonworts are adapted to disturbance and early successional habitats (Wagner and Wagner 1993, Lellinger 1985, Lesica and Ahlenslager 1996). In addition, Farrar and Johnson-Groh (1990) reported that some other species of *Botrychium* can produce aboveground sporophytes from underground asexual propagules called gemmae. This form of vegetative reproduction could provide an advantage in habitats that are often very dry, and may also explain the high plant densities seen in populations of some *Botrychium* species (Farrar and Johnson-Groh 1990).

Another significant factor in the habitat of moonworts is that they depend on mycorrhizal relationships. All *Botrychium* species are believed to be obligately dependent on mycorrhizal fungi in both gametophyte (Bower 1926, Gifford and Foster 1989, Scagel et al. 1966, Schmid and Oberwinkler 1994) and sporophyte generation (Bower 1926, Gifford and Foster 1989, Wagner and Wagner 1981). The gametophyte is subterranean and achlorophyllous, depending on an endophytic fungus for carbohydrate nutrition, while the roots of the sporophyte lack root hairs and probably depend on the fungus for absorption of water and minerals (Gifford and Foster 1989). Little is known about the mycorrhizal fungi associated with *Botrychium* species other than their presence within the gametophyte and roots of the sporophyte (Camacho 1996).

F. Land Ownership

Three populations lie within Glacier National Park, where development is strictly controlled, thus affording a degree of protection. One population is located south of the town of Saint Mary along Highway 89. This site is under ownership of the Blackfeet Tribe or individuals of the Tribe. The Montana Highway Department has an easement through the property and performs the maintenance associated with the highway. The historic locality in Lake County, Montana lies on the Flathead Reservation east of Saint Ignatius in the Mission Mountains. It is within the Reservation Wilderness area and the Tribal Council controls access.

IV. Assessment and Management Recommendations

A. Potential Threats to Currently Known Populations

All four recently documented populations of *Botrychium lineare* in Montana are located along roadways. The three within Glacier National Park are associated with secondary roads that have significant summer traffic. The Saint Mary Ridge population is located along a major highway with greater traffic volume, however the plants themselves are farther from the actual roadway. All of these populations are at risk from exotic weed encroachment, both through increased competition and from control efforts, especially herbicide spraying. In two locations – Saint Mary Ridge and Apikuni Flat – spotted knapweed (*Centaurea maculosa*) was found growing close or immediately adjacent to *B. lineare* plants. Spotted knapweed is designated as a Category 1 noxious weed in Montana, and control is mandated by the state. Herbicide controls may pose the most direct threat to the Saint Mary Ridge population.

The narrow road shoulders in Glacier National Park are routinely mowed during the summer months. This is, in part, an effort to reduce woody plant succession along the edge of the roadway. Mowing maintains the open habitat that *Botrychium lineare* seems to favor by removing most of the canopy and much of the vegetative competition. One adverse effect observed during the summer of 2003 was physical damage to some individual plants from mowing, caused either from flying debris or possibly from the wind forces generated by the large tractor-operated mowers. No evidence was found that the mower blade itself damaged plants directly. Mowing damage was most evident at the Apikuni Flat location and to a lesser degree at the Chief Mountain location. Several plants were observed damaged in this way, and as a result failed to reach maturity and release spores.

Foot and vehicle traffic also impact individual plants. Part of the population closest to Siyeh Bend on Going-to-the-Sun Road is at the road edge adjacent to a popular tourist stopping point and trailhead. Occasional trampling at this location almost certainly occurs (though was not directly observed during our surveys). However, part of this population is several hundred yards to the south and is far enough away from the parking area that it probably receives very little foot traffic.

The Chief Mountain population is close to a trailhead parking area and gets some foot traffic. However, this area is not heavily used and the impacts here appear to be less. At Apikuni Flat the population is very close to the road edge. This road leads to a popular tourist spot with camping and other accommodations. While the population is not directly adjacent to any stopping point, foot and bicycle traffic were observed passing through the area. Vehicle tracks were also noted traveling (off-road) directly through this population later in the summer. Road maintenance could also pose a threat, if it involved major activities such as resurfacing or road expansion.

B. Management Practices and Response

Glacier National Park is managed to maintain natural systems and provide visitors with various recreational opportunities. Expansion of tourist facilities or maintenance of existing facilities, such as larger parking areas or road maintenance, has the potential to impact *Botrychium lineare* populations and any maintenance or expansion plans should consider these localities.

Weed spraying does take place within the park, and weeds that occur within *Botrychium lineare* populations could, with care, be hand pulled or spot sprayed. When mowing close to these populations, the blade of the mower could be raised to avoid damaging plants. Other controls could be employed such as a slower speed of the mower blade or timing the mowing later in the season to reduce injuring plants prior to spore maturity.

Along Highway 89 the spread of weeds is a greater problem, and a carefully applied weed management program could reduce the encroachment of weeds into the Saint Mary Ridge population. This area is

seeing some logging activity, but the likelihood of impacts to the population from logging seem remote.

Fire suppression has been suggested as possibly reducing habitat for this species across its range, as woody plants continue to expand into open meadows. The extensive fires in 2003 within Glacier National Park provide an opportunity to survey for newly established populations in the coming years. There are no data to suggest how long it may take for *Botrychium lineare* to establish after a burn, if indeed it will. In 2002, Saint Mary Ridge east of Highway 89 on the Blackfeet Reservation burned extensively, and this would also be a good area to explore for new populations in future years.

While no signs of cattle grazing were found at any of the *Botrychium lineare* sites in Montana, there is some evidence to suggest that they could be at risk if subjected to intensive grazing in the future. In Washington state, the single known population of *B. lineare* is protected within an exclosure, and no *Botrychium* plants have been found outside the exclosure in habitat heavily grazed by cattle.

C. Conservation Recommendations

The more plants that can successfully mature and release spores, the greater is the likelihood that new plants or populations will be established and that existing populations will be maintained. Although National Park status confers some protection for rare plant populations, future road and facility expansion, changes in land status and increases in visitor and vehicle numbers can pose challenges for the protection and enhancement of plant populations and habitats. Locations less exposed to foot and vehicle traffic are easier to protect and thus provide greater long-term security. Given that known populations of *Botrychium lineare* are located, for the most part, along roadways, a concerted effort to avoid damaging the plants with routine maintenance activities would be the most immediate and obvious conservation measure.

The park and surrounding areas provide abundant potential habitat for this species, and it is likely that other populations exist in both native habitats and secondary habitats created by anthropogenic disturbance. Each new occurrence that is found improves the outlook for long-term viability of this species. Therefore, continued surveys will play an important role in effective conservation planning for this species.

D. Status Recommendations

Occurrences of *Botrychium lineare* in Montana are few, apparently limited in extent, and located in highly disturbed or marginal sites. There is very little information (population trends, recruitment, threats, species longevity) currently available on this species to inform listing recommendations. In addition, new populations continue to be found almost yearly, even though the plant is extremely inconspicuous and difficult to identify.

One of the most serious limitations in our knowledge of this species in Montana is that, to date, we have little information on the natural disturbance processes that have created and maintained habitat for it in the past, since known populations are associated with anthropogenic disturbances, such as roadsides or trails. Because initial establishment of these populations required a source of propagules, we expect that, at least historically, this plant grew in areas where suitable early successional habitat was created and/or maintained by natural disturbance cycles such as fire or grazing. Identifying native habitats that can be maintained by natural, larger scale disturbance regimes will be critical to conservation planning.

We are unable to make a defintive status recommendation for *Botrychium lineare* with the limited information currently available and recommend that survey efforts be continued to develop a better understanding of its distribution and habitat. We recommend focusing surveys in areas of undisturbed or naturally disturbed habitat in the early stages of plant succession. Populations found away from roadsides or other heavily used areas would have reduced threats from ongoing human impacts, though other management issues such as grazing, woody plant encroachment or logging might arise.

It would also be valuable to survey in the area of the historic Mission Mountains population on the Flathead Reservation if permission can be obtained. If that population is extant and can be relocated, it may help to define other native habitats in wooded areas.

E. Interpretation of Survey Results to Date

The early summer of 2003 appeared to provide a good growing season for *Botrychium* species. It has been suggested (Johnson-Groh 1989) that these plants respond as much to moisture conditions in the previous year as in the season during which they are observed. The spring and late summer of 2002 were quite wet, even though July 2002 had record heat throughout much of the state. The early spring of 2003 was also moist and may have provided sufficient moisture for good *Botrychium* growth.

One of the largest populations documented in Montana is at Apikuni Flat in Glacier National Park. This site was reported with 20 to 30 individuals in 1998 and supported over 50 individuals in 2003. The numbers of individual plants that emerge above ground vary greatly from year to year, apparently depending mainly on moisture. With several years' data now available for this site, no trend toward decline is evident.

Because the number of plants at any particular site seems to vary greatly from year to year, depending on growing conditions, any reported decline in the number of plants at a site should be interpreted with great caution. A reduction in above ground plants may not indicate a decline in actual numbers, especially if it is associated with less favorable moisture conditions during that or the preceding year.

Extensive native landscapes were surveyed as part of this project, but we were unable to find any new populations of *Botrychium lineare* in native habitats. It does seem quite probable, however, that there are undiscovered populations of *B. lineare* in the vicinity of Glacier National Park that served as the propagule source for roadside populations, and it may be only a matter of time and survey effort before these populations are discovered.

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APPENDIX A. GLOBAL/STATE RANK DEFINITIONS

Heritage Program Ranks

The international network of Natural Heritage Programs employs a standardized ranking system to denote global (range-wide) and subnational status (NatureServe 2002). Species are assigned numeric ranks ranging from 1 (critically imperiled) to 5 (demonstrably secure), reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks — the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat. Factors in a species' life history that make it especially vulnerable are also considered (e.g., dependence on a specific pollinator).

Global Heritage Status Rank Definitions

GX **Presumed Extinct**—Believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

GH **Possibly Extinct**—Known from only historical occurrences, but may nevertheless still be extant; further searching needed.

G1 **Critically Imperiled**—Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals (<1,000) or acres (<2,000) or linear miles (<10).

G2 **Imperiled**—Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction or elimination. Typically 6 to 20 occurrences or few remaining individu als (1,000 to 3,000) or acres (2,000 to 10,000) or linear miles (10 to 50).

G3 **Vulnerable**—Vulnerable globally either because very rare and local throughout its range, found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extinction or elimination. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.

G4 **Apparently Secure**—Uncommon but not rare (although it may be rare in parts of its range, particularly on the periphery), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern. Typically more than 100 occurrences and more than 10,000 individuals.

G5 **Secure**—Common, widespread, and abundant (although it may be rare in parts of its range, particularly on the periphery). Not vulnerable in most of its range. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

GU **Unrankable**—Currently unrankable due to lack of information or due to substantially conflict ing information about status or trends. NOTE: Whenever possible, the most likely rank is assigned and the question mark qualifier is added (e.g., G2?) to express uncertainty, or a range rank (e.g., G2G3) is used to delineate the limits (range) of uncertainty.

G? **Unranked**—Global rank not yet assessed.

HYB **Hybrid**—Element not ranked because it represents an interspecific hybrid and not a species. (Note, however, that hybrid-derived species are ranked as species, not as hybrids.)

Global Rank Combinations

G#G# **Range Rank**—A numeric range rank (e.g., G2G3) is used to indicate uncertainty about the exact status of a taxon. Ranges cannot skip more than one rank (e.g., GU should be used rather than G1G4).

Global Qualifiers

? **Inexact or Uncertain Numeric Rank**—Denotes inexact numeric rank.

Q **Questionable taxonomy**—Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank.

C **Captive or Cultivated Only**—Taxon at present is extant only in captivity or cultivation, or as a reintroduced population not yet established.

T# **Infraspecific Taxon** (trinomial)—The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.

Subnational Heritage Status Rank Definitions

SX **Presumed Extirpated**—Element is believed to be extirpated from the subnation. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SH **Possibly Extirpated** (Historical)—Element occurred historically in the subnation, and there is some expectation that it may be rediscovered. Its presence may not have been verified in the past 20 years. An element would become SH without such a 20-year delay if the only known occurrences in a subnation were destroyed or if it had been extensively and unsuccessfully looked for. Upon verification of an extant occurrence, SH-ranked elements would typically receive an S1 rank. The SH rank should be reserved for elements for which some effort has been made to relocate occurrences, rather than simply using this rank for all elements not known from verified extant occurrences.

S1 **Critically Imperiled**—Critically imperiled in the subnation because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the subnation. Typically 5 or fewer occurrences or very few remaining individuals (<1,000).

S2 **Imperiled**—Imperiled in the subnation because of rarity or because of some factor(s) making it very vulnerable to extirpation from the subnation. Typically 6 to 20 occurrences or few remain ing individuals (1,000 to 3,000).

S3 **Vulnerable**—Vulnerable in the subnation either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically 21 to 100 occurrences or between 3,000 and 10,000 individuals.

S4 **Apparently Secure**—Uncommon but not rare, and usually widespread in the subnation. Possible cause of long-term concern. Usually more than 100 occurrences and more than 10,000 individuals.

S5 **Secure**—Common, widespread, and abundant in the subnation. Essentially ineradicable under present conditions. Typically with considerably more than 100 occurrences and more than 10,000 individuals.

S? **Unranked**—Subnation rank not yet assessed.

SU **Unrankable**—Currently unrankable due to lack of information or due to substantially conflict ing information about status or trends.

HYB **Hybrid**—Element not ranked because it represents an interspecific hybrid, not a species.

SE **Exotic**—An exotic established in the subnation; may be native in nearby regions (e.g., house finch or catalpa in eastern U.S.).

SE# **Exotic Numeric**—An exotic established in the subnation that has been assigned a numeric rank to indicate its status, as defined for S1 through S5.

SA **Accidental**—Accidental or casual in the subnation, in other words, infrequent and outside usual range. Includes species (usually birds or butterflies) recorded once or only a few times at a location. A few of these species may have bred on the one or two occasions they were recorded. Examples include European strays or western birds on the East Coast and vice-versa.

SZ **Zero Occurrences**—Present but lacking practical conservation concern in the subnation because there are no definable occurrences, although the taxon is native and appears regularly in the subnation. An SZ rank will generally be used for long distance migrants whose occurrences during their migrations have little or no conservation value for the migrant, as they are typically too irregular (in terms of repeated visitation to the same locations), transitory, and dispersed to be reliably identified, mapped, and protected. Although the SZ ranks typically apply to mi grants, it should be used discriminately. SZ only apply when the migrants occur in an irregular, transitory, and dispersed manner.

SP **Potential**—Potential that element occurs in the subnation but no extant or historic occurrences are accepted.

SR **Reported**—Element reported in the subnation but without a basis for either accepting or rejecting the report, or the report not yet reviewed locally. Some of these are very recent discoveries for which the program hasn't yet received first-hand information; others are old, obscure reports.

SSYN **Synonym**—Element reported as occurring in the subnation, but the state data center does not recognize the taxon; therefore the element is not assigned a subnational rank.

***** S rank has been assigned and is under review. Contact the individual subnational Natural Heritage program for assigned rank.
Species is known to occur in this subnation. Contact the individual subnational Natural Heritage program for assigned rank.

Subnational Rank Combinations

S#S# **Range Rank**—A numeric range rank (e.g., S2S3) is used to indicate the range of uncertainty about the exact status of the element. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4).

Subnational Qualifiers

? **Inexact or Uncertain Numberic Rank**—Denotes inexact or uncertain numeric rank.

B **Breeding**—Basic rank refers to the breeding population of the element in the subnation.

N **Nonbreeding**—Basic rank refers to the non-breeding population of the element in the subnation.

C **Captive or Cultivated**—Native element presently extant in the subnation only in captivity or cultivation, or as a reintroduced population not yet established.